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(19)

(54) METHOD AND APPARATUS FOR LINING A PIPE

(71) We, TAKATA KOJYO CO., LTD., a body corporate organized under the laws of Japan, of No. 10 Mori Building, 28 Sakuragawa-cho, Nishikubo, Shiba, Minato-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates generally to a method of and apparatus for lining a pipe, and particularly to a method of repairing large diameter pipes or conduits with difficult access, such as underground sewer pipes or mains for water, gas and utilities.

Long, large diameter pipes are widely employed in the transportation of fluids, both liquid and gaseous, such as sewer pipes, water mains and gas mains. Such pipes are usually accessible along their full lengths only with great difficulty, being either underground or in remote areas. Moreover, these pipes require frequent repair, since they are often ruptured, weakened and otherwise damaged. This damage is commonly a consequence of such occurrences and conditions as abrupt or radical changes in the differential pressure internally and externally of the pipe, ambient foundation or earth movements resulting from many causes, corrosion and erosion, and many other causes. In order to maintain the service afforded by an underground pipe, any serious leaks must be promptly detected and repaired, and such repair generally requires the replacement of a long length of large diameter pipe, since the repair of a section of the pipe by welding, patching or otherwise, is usually unsatisfactory and very difficult. However, particularly in the case of an underground pipe, the replacement of the pipe is difficult, expensive and very time consuming and hence very inefficient, since structurally the pipe is still sound overall and except for weak areas and the points of rupture, still possess a long life expectancy. Not only is it necessary to dig a trench along and beyond the full length of the pipe section to permit its replacement, but the transport of the large pipe to and from the site is difficult, expensive and time consuming, as is the handling and manipulation of the pipe which may necessitate the use of heavy crane equipment. Accordingly, the common practice in the maintenance and servicing of underground pipes and mains is expensive, time consuming and difficult and otherwise leaves much to be desired.

According to the invention there is provided a method of lining a pipe comprising inserting in the pipe a synthetic organic polymeric resin tube having reinforcing fibres embedded therein and extending peripherally thereof and having an outside diameter less than the inside diameter of the pipe, expanding the tube while in a soft flexible condition at an elevated temperature into a tight engagement with the inside face of the pipe by means of a pressurized fluid within the tube, and relieving the fluid pressure and cooling the tube while in engagement with the pipe.

The resin composition may be thermoplastic, for example, a thermoplastic polyvinyl chloride or polyolefin, or may be an uncured soft thermosetting resin containing a heat activated curing agent or a curing agent and a heat deactivated curing retarding agent. Examples of suitable thermosetting compositions are described in British Patent No. 1,360,678. Where a thermoplastic resin repair tube is employed, after it is heated and expanded it is advantageously permitted to cool before the pressure therein is relieved, and

where a thermosetting resin tube is employd, the pressure and heat are maintained until the tube has set. The outside face of the tube or the inside face of the pipe may have an adhesive applied thereto, preferably a temperature sensitive adhesive to ensure a suitable bonding of the pipe and tube at their interface. The repair tube is advantageously reinforced with natural or synthetic fibres, for example polyester, polyamide or glass fibres. Advantageously the fibres extend peripherally and longitudinally with the peripheral fibres having a high non-recoverable elongation whereas the longitudinal fibres are of low elongation. Preferably the repair tube has a reinforcing woven web embedded therein in which the warp extends longitudinally and is of low elongation, and the weft extends peripherally and is of high elongation, for example, unstretched or low stretched polyester or polyamide filaments or yarns.

The method of the invention can be employed to great advantage in the repair of ruptured underground pipes, such as mains. Man or access holes, when not present, are dug at opposite ends of the ruptured pipe sections after the pipe has been suitably emptied and the section is uncoupled from adjacent sections to provide access to its interior. The collapsed liner tube is inserted into the cleaned pipe and clamped by end plates to the pipe end, and a hot pressurized fluid, for instance, air, is then circulated through the tube until it expands, and if formed of a thermosetting resin composition, until it is cured or set. The end plates are then removed and the repaired pipe section is recoupled to the adjacent pipe sections. In the case of sewerage pipes, man holes are generally present at opposite ends of successive pipe sections so that any digging or coupling and uncoupling operations are not necessary. Moreover, the present lining method may be applied to undamaged pipe before the installation or laying thereof. The procedure is simple, reliable and rapid and requires little skilled labour.

In the accompanying drawings:

Figure 1 is a fragmentary transverse sectional view of a liner tube employed in the method of the invention.

Figure 2 is a longitudinal sectional view of a ruptured underground main preparatory to its repair; and

Figure 3 is a view similar to Figure 2 illustrating a step in the repair procedure.

The drawings illustrate a liner tube A for repairing a damaged underground main section B covered by overlying material 12, the material 12 being paved or unpaved, depending on its location. The main section B in its unprepaired state, is shown as having a rupture 4 with ragged inwardly depressed border 4′, the debris 5 from the rupture 4 being accumulated on the bottom of main section B underlying the rupture 4.

The liner tube A includes a matrix 3 formed of a thermoplastic resin or of a soft thermosetting resin composition of the nature set forth above and having a latent curing or cross linking agent. An example of a suitable resin composition in a latent thermosettable state is as follows:—

Ingredient	Parts by Weight
Polyvinyl chloride resin	100
Arylester Thermosetting plasticizer (Tetraethylene glycol dimethacrylate)	40
Di-iso octyl phthalate	20
Stabilizer (CD.Ba stearate)	3
Thermosetting initiator (Di-t-butyl perbenzoate)	2

The resin in its normal cured state at room temperature has a hardness of approximately 85 (Shore D) at 20°. The first stage hardness of the resin in approximately 45 (Shore D). The thickness of tube A iis advantageously between 2mm and 100 mm.

The matrix 3 has embedded therein and bonded thereto a cylindrical reinforcing web including longitudinally extending fibres 1 and peripheral fibres 2 having the compositions earlier set forth. The fibres 1 and 2 are advantageously interwoven and define a fabric warp and weft respectively. The warp 1 is of low elongation for example, stretch oriented polyester of polyamide or glass fibres, and the weft 2 is of high elongation, such as unstretched polyester or polyamide fibres. For example, fibres 1 may be of an elongation of 10% and fibres 2 an elongation of 100% with a maximum elongation at break of at least 600% with a non-recoverable elongation of at least 25%.

In repairing the damaged main section B (which has coupling flanges 6 at opposite ends thereof), the immediate pipe system, if a pressurized gas or water main, is first emptied of the gas or water, access to the ends of the main section B is obtained through preformed manholes or by digging man holes or trenches 7 and 7′ at opposite ends of the main section B and uncoupling and removing the short connector pipe sections 6′ connecting the main section B to adjacent pipe sections. The holes 7 may be manually dug or may be dug by conventional power equipment. Upon obtaining access to the opposite ends of the main section B the debris 5 is removed and the inside face of the main section B is cleaned.

The equipment employed in applying the tube A to the cleaned ruptured main section B includes a pair of centrally apertured end plates 9 and 9′ of approximately the diameter of the pipe end flanges 6, suit-

able means being provided for releasably hermetically clamping the end plates 9 and 9′ to respective flanges 6, for example, the end plates and flanges may be provided with correspondingly spaced apertures for accommodating bolts to effect their tight interconnection. A portable air heating unit 10 has an outlet connected by a flexible hose to the aperture in end plate 9 and an inlet connected to the outlet of a motor driven air circulating blower 11 whose inlet is connected by a flexible hose to the aperture in the other end plate 9′. Conventional means are provided for regulating the temperature of the circulating air produced by the heating unit 10 by controlling the unit 10 in known manner and means may be provided for introducing additional air into the circulating system to increase the pressure therein in the event that the heat expansion thereof is insufficient to fully expand the tube A and the pressure may otherwise regulated.

In applying the tube A, whose outside diameter is considerably less than the inside diameter of the main section B to the inside face of the main section B, a section 8 of tube A is inserted along the length of the main section B and its opposite ends are expanded and the end borders turned outwardly to form end flanges which are sandwiched and clamped between end plates 9 and 9′ and respective pipe flanges 6 and the end plates are clamped to the flanges 6. The heating unit 10 and the blower 11 are then energized to heat and circulate air through the tube section 8 to expand the circulating air which may be further pressurized by pumping additional air therein, the heated circulating air at increased pressure expanding the tube section 8′ and non-recoverably elongating the peripheral fibres 2 so that the expanded tube section 8 firmly hugs and adheres to the inside face of main section B, sealing the rupture 4 as well as the entire inside face of the main section B. The heated air circulation is continued until the resin forming the tube has cured or thermoset, for example with the specific resin specified above, the air is circulated at a temperature of about 40°C to 200°C for a period of 10 to 500 minutes, the fibres 2 having been stretch oriented and retaining their stretched condition by reason of the stretching thereof.

After the setting or cross linking of the resin, as above, the heating unit 10 and blower 11 are denergized, the pressure in the system is relieved, the expanded tube cooled, and the end plates unclamped from flanges 6 and raised through holes 7. The main section B is then recoupled by means adjacent pipe sections and, if desired, the holes 7 are refilled to complete the operation.

It should be noted that in the above operation the expanded tube 8′ will usually bond to the inside face main section B, although this is not necessary, particularly where the hardness of the expanded treated tube 8′, whether the resin is thermo-plastic or thermosetting, is at least self supporting in the absence of internal pressure. However, in many cases it is desirable that the tube and pipe be adherent to each other, and where bonding is not normally effected by the above procedure, a layer of adhesive or cement, advantageously of a heat sensitive or activated nature is applied to the outside face of tube 8 or the inside face of main section B so that they are firmly bonded or secured at their interface.

WHAT WE CLAIM IS:—

1. A method of lining a pipe comprising inserting in the pipe a synthetic organic polymeric resin tube having reinforcing fibres embedded therein and extending peripherally thereof and having an outside diameter less than the inside diameter of the pipe, expanding the tube while in a soft flexible condition at an elevated temperature into tight engagement with the inside face of the pipe by means of a pressurized fluid within the tube, and relieving the fluid pressure and cooling the tube while in engagement with the pipe.

2. A method according to Claim 1, wherein the resin is thermoplastic.

3. A method according to Claim 1, wherein the tube is formed of a heat settable thermosetting resin composition, and the pressurized fluid is heated and circulated through the tube until said resin is substantially set.

4. A method according to any preceding Claim, wherein the fibres are of high elongation and are non-recoverably elongated with the expansion of the tube.

5. A method according to any preceding Claim, wherein the fibres are defined by the weft of a woven web embedded in the tube.

6. A method according to any preceding claim, comprising applying end plates to the ends of the pipe and clamping the end borders of the tube between the end plates and corresponding ends of the tube and circulating a heated gas through the tube by way of openings in the end plates.

7. A method according to any preceding claim, comprising applying an adhesive to at least one of the confronting peripheral faces of the pipe and the tube prior to the expansion of the tube.

8. A method according to any preceding claim wherein the pipe includes a first underground section coupled at opposite ends to adjacent second pipe sections, and including the steps of digging holes at the

opposite ends of the first pipe section and uncoupling the first section from the second sections to provide access to the first section and inserting the tube into the first section prior to the expansion of the tube.

9. A method of lining a pipe, substantially as herein described with reference to the accompanying drawing.

10. An apparatus for carrying out the method of Claim 1, comprising a gas heating and circulating means having an inlet and an outlet, a pair of end plates adapted for sealing engagement with the ends of the pipe and each having a part therein and means including flexible hoses connecting the inlet and outlet to the respective ports.

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1 SHEET This drawing is a reproduction of the Original on a reduced scale

Fig.1.

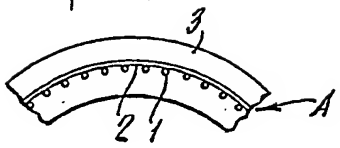

Fig.2.

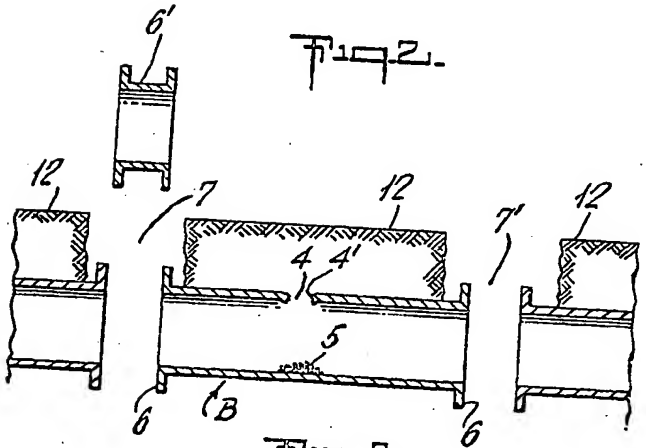

Fig.3.